A natural approach to optimal forecasting in case of preliminary observations

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A NATURAL APPROACH TO OPTIMAL FORECASTING IN CASE OF PRELIMINARY OBSERVATIONS

Theo Nijman

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A NATURAL APPROACH TO OPTIMAL FORECASTING

IN CASE OF PRELIMINARY OBSERVATIONS

Theo Nijman *
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Abstract

Several authors have proposed to use Kalman filtering techniques to compute MMSE forecasts if the most recent observations are known to be preliminary only. In this note we propose simpler and more natural approach to this problem. First we test for the rationality of the preliminary data and, if necessary, correct for irrationalities. Subsequently MMSE forecasts can be computed as if the most recent observations were final. Moreover, simple expressions which can be used to evaluate the variance of the prediction errors are available.

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1. Introduction

In many countries preliminary estimates of macro-economic variables and indicators are published several months before a final figure becomes available. In this note we consider the computation of minimum mean square error (MMSE) predictors if the most recent data are preliminary only. For simplicity we concentrate on univariate ARIMA models. The results can be straightforwardly extended to multivariate models.

Assume that a variable y_t is generated by the (possibly non-stationary) ARIMA model with AR(∞) representation

$$y_t = c + \sum_{i=1}^{\infty} \varphi_i \, y_{t-i} + \varepsilon_t \qquad \varepsilon_t \sim IN(0,\sigma_\varepsilon^2) \tag{1}$$

and assume that a data collecting agency observes and publishes y_{t-K} in period t. Assume moreover that the data collecting agency publishes preliminary estimates ${}_t y_{t-k}$ of y_{t-k} $(k = 0,\dots,K-1)$ in period t. The problem to be considered is the computation of MMSE forecasts of y_{T+h} from information which is available in period T, i.e. the computation of

$$\hat{y}_{T+h} = E[y_{T+h} \mid {}_T y_T, {}_T y_{T-1}, \dots, {}_T y_{T-K+1}, y_{T-K}, y_{T-K-1}, \dots]. \tag{2}$$

In Howrey (1978,1983), Harvey et.al. (1984) and Bordignon and Trivellato (1989) among others, this problem is addressed by specifying the distribution of the preliminary data conditional on the true values as

$${}_t y_{t-k} = \alpha_k + \beta_k \, y_{t-k} + w_{kt}, \qquad (k = 0,\dots,K-1) \tag{3}$$

with the vector of measurement errors $w_t = [w_{0t},\dots,w_{K-1,t}]'$ independent of y_s $(\forall t,s)$ and with w_t generated by a vector ARMA model. The α_k's and β_k's in the observation equation (3) are typically treated as unknown parameters to be estimated. If this model is valid the recursive Kalman filter can be used to compute the maximum likelihood estimates of the parameters in (1) and (3) and to evaluate the expectation in (2) after the model has been written in state space form.

Although (3) might be an attractive assumption if ${}_t y_{t-k}$ is simply a direct measurement of y_{t-k}, based e.g. on a small sample preliminary survey, it ignores the fact that the data collecting agency has an incentive to publish preliminary data which are rational in the sense that

$$E[y_{t-k} | {}_t y_t, \dots, {}_t y_{t-K+1}, y_{t-K}, y_{t-K-1}, \dots] = {}_t y_{t-k} \qquad (k=0,\dots,K-1) \quad (4)$$

which is not implied by (3). In section 4 we will show that the computation of MMSE forecasts and the associated prediction intervals is greatly simplified if (4) holds and does not require the use of recursive Kalman filters. Before we turn to the derivation of forecasts from rational preliminary data however, we consider the relation between (3) and (4) in more detail for the special case of only one revision (K = 1) in section 2 and discuss tests of assumption (4) in section 3.

2. The case of one revision

In order to illustrate the relation between (3) and (4) assume that K = 1 and that the data collecting agency receives in period t a direct measurement m_t of y_t based e.g. on some small sample preliminary survey,

$$m_t = y_t + u_t. \qquad (5)$$

Assume that the measurement error u_t is independent of past, present and future values of y_t and that it is generated by a stationary ARIMA model with AR(∞) representation

$$u_t = \sum_{i=0}^{\infty} \rho_i u_{t-i} + e_t. \qquad e_t \sim IN(0,\sigma_e^2) \qquad (6)$$

Use of the recursive projection theorem (see e.g. Sargent (1979), p. 208) shows that a rational data collecting agency, which behaves similarly to the agency in the second model in Sargent (1989), will publish as their preliminary estimate of y_t the variable ${}_t y_t^r$ defined by

$${}_t y_t^r = E[y_t | m_t, m_{t-1}, \dots, y_{t-1}, y_{t-2}, \dots] =$$

$$= c + \sum_{i=1}^{\infty} \varphi_i y_{t-i} + E[\varepsilon_t | m_t - E[m_t | m_{t-1}, m_{t-2}, \ldots, y_{t-1}, y_{t-2}, \ldots]] =$$

$$= c + \sum_{i=1}^{\infty} \varphi_i y_{t-i} + E[\varepsilon_t | \varepsilon_t + e_t] =$$

$$= c + \sum_{i=1}^{\infty} \varphi_i y_{t-i} + \lambda \{m_t - c - \sum_{i=1}^{\infty} \varphi_i y_{t-i} - \sum_{i=1}^{\infty} \rho_i (m_{t-i} - y_{t-i}) \}, \quad (7)$$

where $\lambda = \sigma_\varepsilon^2 (\sigma_\varepsilon^2 + \sigma_e^2)^{-1}$.

Evidently, if m_t is published as the preliminary estimate, (3) is satisfied by assumption and similarly (4) is satisfied if ${}_t y_t = {}_t y_t^r$. Although by construction ${}_t y_t^r$ satisfies (4) this does not imply that (3) is misspecified if ${}_t y_t = {}_t y_t^r$ however. If y_t is stationary with variance σ_y^2 one can easily check that

$$E[{}_t y_t | y_t] = E[y_t - (1-\lambda)\varepsilon_t + \lambda e_t | y_t] = \{1-(1-\lambda)\sigma_\varepsilon^2 \sigma_y^{-2}\} y_t = \beta y_t, \quad (8)$$

where β is defined by the last equality in (8). The corresponding error term w_{0t} in (3) can be written as

$$w_{0t} = {}_t y_t - \beta y_t = (1-\beta) y_t + \lambda e_t - (1-\lambda) \varepsilon_t. \quad (9)$$

If y_t is generated by a stationary ARMA(p,q) model, the measurement error term w_{0t} will be generated by an ARMA(p,max(p,q)) process (see e.g. Harvey (1981), p. 43) as assumed in (3). Contrary to the assumption in (3) however, lagged values of y_t will not be independent of w_{0t} if the revision process is rational. Therefore if ${}_t y_t = {}_t y_t^r$ and if y_t is stationary, (3) probably fits the data reasonably well but is formally misspecified. If y_t is non-stationary on the other hand, which is probably the more interesting case from the point of view of applications, y_t and ${}_t y_t^r$ will be cointegrated implying that $\beta = 1$ and that (3) is correctly specified even if the revisions are rational and that actually w_{0t} is a white noise error. If $\beta = 1$ is not imposed a priori one should not be too surprised to find autocorrelation in w_{0t} however. Suppose e.g. that one estimates the autocorrelation in w_{0t} using the autocorrelation in the residuals $\hat{w}_{0t}$ of a regression of ${}_t y_t^r$ on y_t. Assuming $c \neq 0$ and defining $v_t = \lambda\, e_t + (1-\lambda)\, \varepsilon_t$ one can write

$$\operatorname{plim} T^{-1} \sum_{t=k+1}^{T} \hat{w}_{0t} \hat{w}_{0t-k} = \operatorname{plim} T^{-1} \Sigma \{(\beta-\hat{\beta}) y_t + v_t\}\{(\beta-\hat{\beta}) y_{t-k} + v_{t-k}\}$$

$$= \operatorname{plim} \{T(\beta-\hat{\beta})\}^2\, T^{-3} \Sigma y_t y_{t-k} \neq 0 \qquad (10)$$

because $T(\beta-\hat{\beta})$ and $T^{-3} \sum_{t=k+1}^{T} y_t y_{t-k}$ converge to a non-degenerate distribution (see e.g. Stock (1987)) and a non-zero constant respectively. Note that a similar problem does not arise if y_t is stationary.

3. Tests for the rationality of the revisions and corrections for irrationalities

The crucial assumption which simplifies the computation of MMSE forecasts in a way to be described in section 4 is that revisions are rational, i.e. that (4) holds. Howrey (1984), Mankiw et.al. (1984), Mankiw and Shapiro (1986), Mork (1987) and de Jong (1987) among others have considered procedures to test this assumption. A simple test is to estimate

$$y_{t-k} = \sum_{i=0}^{K-1} \gamma_{ki}\, {}_t y_{t-i} + \sum_{i=0}^{L} \delta_{ki}\, y_{t-K-i} + \nu_{kt} \qquad (11)$$

by OLS for $k = 0,\ldots,K-1$ and a sufficiently large value of L and to test the hypothesis H_0: $\gamma_{kk} = 1$, $\gamma_{ki} = 0$ $(i \neq k)$ and $\delta_{ki} = 0$. Note however that ν_{kt} is autocorrelated under H_0 if $k < K-1$ so that the test statistic can not be based on the standard estimate of the variance-covariance matrix of parameters in a regression model (see e.g. Mork (1987)).

Data collecting agencies have an incentive to publish data which are not subject to forecastable revisions. On the other hand, as recently stressed by Mork (1987), government agencies might have an incentive to conservatism to avoid criticism for "false signals" in which case (4) would be violated. If the tests reject it is straightforward however to correct for irrationalities by treating

$$y^{c}_{t-k} = \sum_{i=0}^{K-1} \hat{\gamma}_{ki}\ {}_{t}y_{t-i} + \sum_{i=0}^{L} \hat{\delta}_{ki}\ y_{t-K-i} \tag{12}$$

where $\hat{\gamma}_{ki}$ and $\hat{\delta}_{ki}$ denote the regression estimates form (11) as the corrected preliminary estimate of y_{t-k} which satisfies (4) by construction.

4. Forecasts based on rational preliminary data

If a data collecting agency publishes rational preliminary data, or if these have been constructed using the procedures described in the previous section, the computation of MMSE forecasts and the associated prediction intervals is straightforward and does not require the use of recursive Kalman filters. In order to derive the predictor and the prediction interval write

$$y_{T+h} = \sum_{i=0}^{\infty} \varphi_{hi}\ y_{T-i} + \sum_{i=0}^{h-1} \alpha_{i}\ \varepsilon_{T+h-i} \tag{13}$$

which defines the coefficients φ_{hi}. These coefficients can easily be computed recursively using the fact that $\varphi_{hi} = \sum_{j=0}^{\infty} \varphi_{j}\ \varphi_{h-j,i}$ where the recursions are started up setting $\varphi_{hi} = 0$ if $h \leq 0$ and $h \neq -i$ and $\varphi_{h,-h} = 1$ if $h \leq 0$. If (4) holds the MMSE forecast is

$$E[y_{T+h} | {}_{T}y_{T}, {}_{T}y_{T-1}, \ldots, {}_{T}y_{T-K+1}, y_{T-K}, y_{T-K-1}, \ldots] = \tag{14}$$

$$E[\sum_{i=0}^{\infty} \varphi_{hi} y_{T-i} | {}_{T}y_{T}, \ldots, {}_{T}y_{T-K+1}, y_{T-K}, y_{T-K-1}, \ldots] = \sum_{i=0}^{\infty} \varphi_{hi}\ {}_{T}y_{T-i},$$

where we defined ${}_{T}y_{T-i} = y_{T-i}$ $(i \geq K)$ for notational simplicity. The predictor in (14) can of course be computed using standard software by treating the preliminary data as if they are final. Although this procedure is referred to as "naive" by e.g. Harvey et.al. (1983) and Bordignon and Trivellato (1989) it is optimal if the revisions are rational.

Standard software will compute an estimate of $\sigma_\varepsilon^2 \sum_{i=0}^{h-1} \alpha_i^2$ as the variance of the prediction error. The correct result in case of rational preliminary data is

$$E[\,(y_{T+h}-\Sigma_i\, \varphi_{ki}\; {}_Ty_{T-i})^2 \mid {}_Ty_T, \ldots, {}_Ty_{T-K+1}, y_{T-L}, y_{T-L-1}, \ldots\,] =$$

$$E[\{\sum_{i=0}^{h-1} \alpha_i\, \varepsilon_{t-i} + \sum_{i=0}^{K-1} \varphi_{hi}\, (y_{T-i}-{}_Ty_{T-i})\}^2 | {}_Ty_T,..,{}_Ty_{T-L+1}, y_{T-L}, y_{T-L-1},] =$$

$$\sum_{i=0}^{h-1} \alpha_i^2\, \sigma_\varepsilon^2 + \sum_{i,j=0}^{K-1} \varphi_{hi}\varphi_{hj}\, r_{ij}, \tag{15}$$

where $r_{ij} = E\,(y_{t-i}-{}_ty_{t-i})(y_{t-j}-{}_ty_{t-j})$. Because the φ_{hi} can be computed recursively for $h = 1,2,\ldots$ and because r_{ij} can be estimated consistently from historical revisions, the standard estimate of the variance of the prediction error can easily be corrected for the presence of preliminary data.

5. Concluding remarks

Several authors have proposed to use Kalman filtering techniques to compute MMSE forecasts if the most recent observations are known to be preliminary only. In this note we proposed a more natural and simpler approach to this problem which was based on the distribution of the true value conditional on the preliminary estimates instead of the other way around. First we test for the rationality of the preliminary data and if necessary correct for irrationalities. Subsequently MMSE forecasts can be computed as if the most recent observations were final. Moreover, simple expressions which can be used to evaluate the variance of the prediction errors are available.

References

Bordignon, S. and U. Trivellato (1989), "The optimal use of provisional data in forecasting with dynamic models", Journal of Business and Economic Statistics, 7, 2, p. 275 - 286.

Jong, P. de (1987), "Rational Economic Data Revisions", Journal of Business and Economic Statistics, 5, 4, p. 539 - 548.

Harvey, A.C. (1981), "Time Series Models", Philip Allan, Oxford.

Harvey, A.C., McKenzie, C.R., Blake, D.P.C., and M.J. Desai (1983), "Irregeluar data revisions", in Applied Time Series Analysis of Economic Data, ed. A. Zellner, U.S. Dept. of Commerce, Bureau of the Census, Washington D.C.

Howrey, E.P. (1978), "The use of preliminary data in econometric forecasting", The Review of Economics and Statistics, 60, p. 193-200.

Howrey, E.P. (1984), "Data revision, reconstruction and prediction: an application to inventory investment", The Review of Economics and Statistics, 60, p. 386 - 393.

Mankiw, N.G., Runkle, D.E. and M.D. Shapiro (1984), "Are preliminary announcements of the money stock rational forecasts ?", Journal of Monetary Economics, 14, p. 15 - 27.

Mankiw, N.G. and M.D. Shapiro (1986), "News or noise? An analysis of GNP revisions", Survey of Current Business, 66, p. 20-25.

Mork, K.A. (1987), "Ain't behavin': Forecast errors and measurement errors in early GNP estimates", Journal of Business and Economic Statistics, 5, 2, p. 165 - 175.

Sargent, T.J. (1979), "Macroeconomic Theory", Academic Press, New York.

Sargent, T.J. (1989), "Two models of measurements and the investment accelerator", Journal of Political Economy, 97, 2, p. 251 - 287.

Stock, J. (1987), "Asymptotic properties of least squares estimators of cointegrating vectors", Econometrica, 55, p. 1035-1056.

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